

Quantifying Effectiveness of Activity

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INTRODUCTION

Using devices such as Jawbone Up, Nike FuelBand, and Fitbit it is now possible to collect a large amount of data about personal activity relatively inexpensively. These type of devices are part of the quantified self movement - a group of enthusiasts who take measurements about themselves regularly to improve their health, to find patterns in their behavior, or because they are tech geeks. One thing that people regularly do is quantify how much of a particular activity they do, but they rarely quantify how well they do it.

In this project, I will use data from accelerometers on the belt, forearm, arm, and dumbbell of 6 participants. They were asked to perform barbell lifts correctly and incorrectly in 5 different ways.

More information is available from the website here: <http://groupware.les.inf.puc-rio.br/har> (see the section on the Weight Lifting Exercise Dataset).

DATA

The data for this project come from : <http://groupware.les.inf.puc-rio.br/har>.

Explore the Data sets

```
dim(training)
```

```
## [1] 19622 160
```

```
dim(testing)
```

```
## [1] 20 160
```

```
summary(training)
```

```
##           X           user_name  raw_timestamp_part_1 raw_timestamp_part_2
## Min.      :    1   adelmo :3892   Min.      :1.322e+09   Min.      : 294
## 1st Qu.: 4906   carlitos:3112   1st Qu.:1.323e+09   1st Qu.:252912
## Median : 9812   charles :3536   Median :1.323e+09   Median :496380
## Mean    : 9812   eurico  :3070   Mean    :1.323e+09   Mean    :500656
## 3rd Qu.:14717   jeremy  :3402   3rd Qu.:1.323e+09   3rd Qu.:751891
## Max.    :19622   pedro   :2610   Max.    :1.323e+09   Max.    :998801
##
##           cvtd_timestamp  new_window  num_window  roll_belt
## 28/11/2011 14:14: 1498   no :19216   Min.      : 1.0   Min.      : -28.90
## 05/12/2011 11:24: 1497   yes: 406    1st Qu.:222.0   1st Qu.: 1.10
## 30/11/2011 17:11: 1440                      Median :424.0   Median :113.00
## 05/12/2011 11:25: 1425                      Mean    :430.6   Mean    : 64.41
## 02/12/2011 14:57: 1380                      3rd Qu.:644.0   3rd Qu.:123.00
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## 02/12/2011 13:34: 1375          Max.   :864.0   Max.   :162.00
## (Other)           :11007
##   pitch_belt      yaw_belt      total_accel_belt kurtosis_roll_belt
## Min.   :-55.8000   Min.   :-180.00   Min.   : 0.00           :19216
## 1st Qu.: 1.7600   1st Qu.: -88.30   1st Qu.: 3.00   #DIV/0! : 10
## Median : 5.2800   Median : -13.00   Median :17.00   -1.908453: 2
## Mean   : 0.3053   Mean   : -11.21   Mean   :11.31   -0.016850: 1
## 3rd Qu.:14.9000   3rd Qu.: 12.90   3rd Qu.:18.00   -0.021024: 1
## Max.   : 60.3000   Max.   : 179.00   Max.   :29.00   -0.025513: 1
##                                     (Other) : 391
## kurtosis_picth_belt kurtosis_yaw_belt skewness_roll_belt
##           :19216           :19216           :19216
## #DIV/0! : 32   #DIV/0! : 406   #DIV/0! : 9
## 47.000000: 4           0.000000 : 4
## -0.150950: 3           0.422463 : 2
## -0.684748: 3           -0.003095: 1
## -1.750749: 3           -0.010002: 1
## (Other) : 361           (Other) : 389
## skewness_roll_belt.1 skewness_yaw_belt max_roll_belt   max_picth_belt
##           :19216           :19216   Min.   :-94.300   Min.   : 3.00
## #DIV/0! : 32   #DIV/0! : 406   1st Qu.: -88.000   1st Qu.: 5.00
## 0.000000 : 4           Median : -5.100   Median :18.00
## -2.156553: 3           Mean   : -6.667   Mean   :12.92
## -3.072669: 3           3rd Qu.: 18.500   3rd Qu.:19.00
## -6.324555: 3           Max.   :180.000   Max.   :30.00
## (Other) : 361           NA's   :19216   NA's   :19216
##   max_yaw_belt   min_roll_belt   min_pitch_belt   min_yaw_belt
##           :19216   Min.   :-180.00   Min.   : 0.00           :19216
## -1.1 : 30   1st Qu.: -88.40   1st Qu.: 3.00   -1.1 : 30
## -1.4 : 29   Median : -7.85   Median :16.00   -1.4 : 29
## -1.2 : 26   Mean   : -10.44   Mean   :10.76   -1.2 : 26
## -0.9 : 24   3rd Qu.: 9.05   3rd Qu.:17.00   -0.9 : 24
## -1.3 : 22   Max.   : 173.00   Max.   :23.00   -1.3 : 22
## (Other): 275   NA's   :19216   NA's   :19216   (Other): 275
## amplitude_roll_belt amplitude_pitch_belt amplitude_yaw_belt
## Min.   : 0.000   Min.   : 0.000           :19216
## 1st Qu.: 0.300   1st Qu.: 1.000   #DIV/0! : 10
## Median : 1.000   Median : 1.000   0.00 : 12
## Mean   : 3.769   Mean   : 2.167   0.0000 : 384
## 3rd Qu.: 2.083   3rd Qu.: 2.000
## Max.   :360.000   Max.   :12.000
## NA's   :19216   NA's   :19216
## var_total_accel_belt avg_roll_belt   stddev_roll_belt var_roll_belt
## Min.   : 0.000   Min.   : -27.40   Min.   : 0.000   Min.   : 0.000
## 1st Qu.: 0.100   1st Qu.: 1.10   1st Qu.: 0.200   1st Qu.: 0.000
## Median : 0.200   Median :116.35   Median : 0.400   Median : 0.100
## Mean   : 0.926   Mean   : 68.06   Mean   : 1.337   Mean   : 7.699
## 3rd Qu.: 0.300   3rd Qu.:123.38   3rd Qu.: 0.700   3rd Qu.: 0.500
## Max.   :16.500   Max.   :157.40   Max.   :14.200   Max.   :200.700
## NA's   :19216   NA's   :19216   NA's   :19216   NA's   :19216
## avg_pitch_belt   stddev_pitch_belt var_pitch_belt   avg_yaw_belt
## Min.   : -51.400   Min.   :0.000   Min.   : 0.000   Min.   : -138.300
## 1st Qu.: 2.025   1st Qu.:0.200   1st Qu.: 0.000   1st Qu.: -88.175
## Median : 5.200   Median :0.400   Median : 0.100   Median : -6.550

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## Mean      : 0.520      Mean      :0.603      Mean      : 0.766      Mean      : -8.831
## 3rd Qu.: 15.775      3rd Qu.:0.700      3rd Qu.: 0.500      3rd Qu.: 14.125
## Max.      : 59.700      Max.      :4.000      Max.      :16.200      Max.      : 173.500
## NA's      :19216      NA's      :19216      NA's      :19216      NA's      :19216
## stddev_yaw_belt      var_yaw_belt      gyros_belt_x
## Min.      : 0.000      Min.      : 0.000      Min.      : -1.040000
## 1st Qu.: 0.100      1st Qu.: 0.010      1st Qu.: -0.030000
## Median : 0.300      Median : 0.090      Median : 0.030000
## Mean      : 1.341      Mean      : 107.487      Mean      : -0.005592
## 3rd Qu.: 0.700      3rd Qu.: 0.475      3rd Qu.: 0.110000
## Max.      :176.600      Max.      :31183.240      Max.      : 2.220000
## NA's      :19216      NA's      :19216
## gyros_belt_y      gyros_belt_z      accel_belt_x      accel_belt_y
## Min.      : -0.64000      Min.      : -1.4600      Min.      : -120.000      Min.      : -69.00
## 1st Qu.: 0.00000      1st Qu.: -0.2000      1st Qu.: -21.000      1st Qu.: 3.00
## Median : 0.02000      Median : -0.1000      Median : -15.000      Median : 35.00
## Mean      : 0.03959      Mean      : -0.1305      Mean      : -5.595      Mean      : 30.15
## 3rd Qu.: 0.11000      3rd Qu.: -0.0200      3rd Qu.: -5.000      3rd Qu.: 61.00
## Max.      : 0.64000      Max.      : 1.6200      Max.      : 85.000      Max.      :164.00
##
## accel_belt_z      magnet_belt_x      magnet_belt_y      magnet_belt_z
## Min.      : -275.00      Min.      : -52.0      Min.      :354.0      Min.      : -623.0
## 1st Qu.: -162.00      1st Qu.: 9.0      1st Qu.:581.0      1st Qu.: -375.0
## Median : -152.00      Median : 35.0      Median :601.0      Median : -320.0
## Mean      : -72.59      Mean      : 55.6      Mean      :593.7      Mean      : -345.5
## 3rd Qu.: 27.00      3rd Qu.: 59.0      3rd Qu.:610.0      3rd Qu.: -306.0
## Max.      : 105.00      Max.      :485.0      Max.      :673.0      Max.      : 293.0
##
## roll_arm      pitch_arm      yaw_arm      total_accel_arm
## Min.      : -180.00      Min.      : -88.800      Min.      : -180.0000      Min.      : 1.00
## 1st Qu.: -31.77      1st Qu.: -25.900      1st Qu.: -43.1000      1st Qu.:17.00
## Median : 0.00      Median : 0.000      Median : 0.0000      Median :27.00
## Mean      : 17.83      Mean      : -4.612      Mean      : -0.6188      Mean      :25.51
## 3rd Qu.: 77.30      3rd Qu.: 11.200      3rd Qu.: 45.8750      3rd Qu.:33.00
## Max.      : 180.00      Max.      : 88.500      Max.      : 180.0000      Max.      :66.00
##
## var_accel_arm      avg_roll_arm      stddev_roll_arm      var_roll_arm
## Min.      : 0.00      Min.      : -166.67      Min.      : 0.000      Min.      : 0.000
## 1st Qu.: 9.03      1st Qu.: -38.37      1st Qu.: 1.376      1st Qu.: 1.898
## Median : 40.61      Median : 0.00      Median : 5.702      Median : 32.517
## Mean      : 53.23      Mean      : 12.68      Mean      : 11.201      Mean      : 417.264
## 3rd Qu.: 75.62      3rd Qu.: 76.33      3rd Qu.: 14.921      3rd Qu.: 222.647
## Max.      :331.70      Max.      : 163.33      Max.      :161.964      Max.      :26232.208
## NA's      :19216      NA's      :19216      NA's      :19216      NA's      :19216
## avg_pitch_arm      stddev_pitch_arm      var_pitch_arm      avg_yaw_arm
## Min.      : -81.773      Min.      : 0.000      Min.      : 0.000      Min.      : -173.440
## 1st Qu.: -22.770      1st Qu.: 1.642      1st Qu.: 2.697      1st Qu.: -29.198
## Median : 0.000      Median : 8.133      Median : 66.146      Median : 0.000
## Mean      : -4.901      Mean      :10.383      Mean      : 195.864      Mean      : 2.359
## 3rd Qu.: 8.277      3rd Qu.:16.327      3rd Qu.: 266.576      3rd Qu.: 38.185
## Max.      : 75.659      Max.      :43.412      Max.      :1884.565      Max.      : 152.000
## NA's      :19216      NA's      :19216      NA's      :19216      NA's      :19216
## stddev_yaw_arm      var_yaw_arm      gyros_arm_x
## Min.      : 0.000      Min.      : 0.000      Min.      : -6.37000

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## 1st Qu.: 2.577 1st Qu.: 6.642 1st Qu.: -1.33000
## Median : 16.682 Median : 278.309 Median : 0.08000
## Mean : 22.270 Mean : 1055.933 Mean : 0.04277
## 3rd Qu.: 35.984 3rd Qu.: 1294.850 3rd Qu.: 1.57000
## Max. : 177.044 Max. : 31344.568 Max. : 4.87000
## NA's : 19216 NA's : 19216
## gyros_arm_y gyros_arm_z accel_arm_x accel_arm_y
## Min. : -3.4400 Min. : -2.3300 Min. : -404.00 Min. : -318.0
## 1st Qu.: -0.8000 1st Qu.: -0.0700 1st Qu.: -242.00 1st Qu.: -54.0
## Median : -0.2400 Median : 0.2300 Median : -44.00 Median : 14.0
## Mean : -0.2571 Mean : 0.2695 Mean : -60.24 Mean : 32.6
## 3rd Qu.: 0.1400 3rd Qu.: 0.7200 3rd Qu.: 84.00 3rd Qu.: 139.0
## Max. : 2.8400 Max. : 3.0200 Max. : 437.00 Max. : 308.0
##
## accel_arm_z magnet_arm_x magnet_arm_y magnet_arm_z
## Min. : -636.00 Min. : -584.0 Min. : -392.0 Min. : -597.0
## 1st Qu.: -143.00 1st Qu.: -300.0 1st Qu.: -9.0 1st Qu.: 131.2
## Median : -47.00 Median : 289.0 Median : 202.0 Median : 444.0
## Mean : -71.25 Mean : 191.7 Mean : 156.6 Mean : 306.5
## 3rd Qu.: 23.00 3rd Qu.: 637.0 3rd Qu.: 323.0 3rd Qu.: 545.0
## Max. : 292.00 Max. : 782.0 Max. : 583.0 Max. : 694.0
##
## kurtosis_roll_arm kurtosis_pitch_arm kurtosis_yaw_arm skewness_roll_arm
## :19216 :19216 :19216 :19216
## #DIV/0! : 78 #DIV/0! : 80 #DIV/0! : 11 #DIV/0! : 77
## -0.02438: 1 -0.00484: 1 0.55844 : 2 -0.00051: 1
## -0.04190: 1 -0.01311: 1 0.65132 : 2 -0.00696: 1
## -0.05051: 1 -0.02967: 1 -0.01548: 1 -0.01884: 1
## -0.05695: 1 -0.07394: 1 -0.01749: 1 -0.03359: 1
## (Other) : 324 (Other) : 322 (Other) : 389 (Other) : 325
## skewness_pitch_arm skewness_yaw_arm max_roll_arm max_pitch_arm
## :19216 :19216 Min. : -73.100 Min. : -173.000
## #DIV/0! : 80 #DIV/0! : 11 1st Qu.: -0.175 1st Qu.: -1.975
## -0.00184: 1 -1.62032: 2 Median : 4.950 Median : 23.250
## -0.01185: 1 0.55053 : 2 Mean : 11.236 Mean : 35.751
## -0.01247: 1 -0.00311: 1 3rd Qu.: 26.775 3rd Qu.: 95.975
## -0.02063: 1 -0.00562: 1 Max. : 85.500 Max. : 180.000
## (Other) : 322 (Other) : 389 NA's : 19216 NA's : 19216
## max_yaw_arm min_roll_arm min_pitch_arm min_yaw_arm
## Min. : 4.00 Min. : -89.10 Min. : -180.00 Min. : 1.00
## 1st Qu.: 29.00 1st Qu.: -41.98 1st Qu.: -72.62 1st Qu.: 8.00
## Median : 34.00 Median : -22.45 Median : -33.85 Median : 13.00
## Mean : 35.46 Mean : -21.22 Mean : -33.92 Mean : 14.66
## 3rd Qu.: 41.00 3rd Qu.: 0.00 3rd Qu.: 0.00 3rd Qu.: 19.00
## Max. : 65.00 Max. : 66.40 Max. : 152.00 Max. : 38.00
## NA's : 19216 NA's : 19216 NA's : 19216 NA's : 19216
## amplitude_roll_arm amplitude_pitch_arm amplitude_yaw_arm
## Min. : 0.000 Min. : 0.000 Min. : 0.00
## 1st Qu.: 5.425 1st Qu.: 9.925 1st Qu.: 13.00
## Median : 28.450 Median : 54.900 Median : 22.00
## Mean : 32.452 Mean : 69.677 Mean : 20.79
## 3rd Qu.: 50.960 3rd Qu.: 115.175 3rd Qu.: 28.75
## Max. : 119.500 Max. : 360.000 Max. : 52.00
## NA's : 19216 NA's : 19216 NA's : 19216

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## roll_dumbbell      pitch_dumbbell      yaw_dumbbell
## Min.      :-153.71  Min.      :-149.59  Min.      :-150.871
## 1st Qu.: -18.49   1st Qu.: -40.89   1st Qu.: -77.644
## Median :  48.17   Median : -20.96   Median :  -3.324
## Mean    :  23.84   Mean    : -10.78   Mean    :   1.674
## 3rd Qu.:  67.61   3rd Qu.:  17.50   3rd Qu.:  79.643
## Max.    : 153.55   Max.    : 149.40   Max.    : 154.952
##
## kurtosis_roll_dumbbell kurtosis_pitch_dumbbell kurtosis_yaw_dumbbell
##          :19216          :19216          :19216
## #DIV/0!:    5          -0.5464:    2          #DIV/0!:  406
## -0.2583:    2          -0.9334:    2
## -0.3705:    2          -2.0833:    2
## -0.5855:    2          -2.0851:    2
## -2.0851:    2          -2.0889:    2
## (Other):  393          (Other):  396
## skewness_roll_dumbbell skewness_pitch_dumbbell skewness_yaw_dumbbell
##          :19216          :19216          :19216
## #DIV/0!:    4          -0.2328:    2          #DIV/0!:  406
## -0.9324:    2          -0.3521:    2
## 0.1110 :    2          -0.7036:    2
## 1.0312 :    2          0.1090 :    2
## -0.0082:    1          1.0326 :    2
## (Other):  395          (Other):  396
## max_roll_dumbbell max_pitch_dumbbell max_yaw_dumbbell min_roll_dumbbell
## Min.      :-70.10   Min.      :-112.90          :19216   Min.      :-149.60
## 1st Qu.: -27.15   1st Qu.: -66.70   -0.6    :    20   1st Qu.: -59.67
## Median : 14.85   Median :  40.05   0.2    :    19   Median : -43.55
## Mean    : 13.76   Mean    :  32.75  -0.8    :    18   Mean    : -41.24
## 3rd Qu.: 50.58   3rd Qu.: 133.22  -0.3    :    16   3rd Qu.: -25.20
## Max.    :137.00   Max.    : 155.00  -0.2    :    15   Max.    :  73.20
## NA's    :19216   NA's    :19216   (Other):  318   NA's    :19216
## min_pitch_dumbbell min_yaw_dumbbell amplitude_roll_dumbbell
## Min.      :-147.00          :19216   Min.      :  0.00
## 1st Qu.: -91.80   -0.6    :    20   1st Qu.: 14.97
## Median : -66.15   0.2    :    19   Median : 35.05
## Mean    : -33.18  -0.8    :    18   Mean    : 55.00
## 3rd Qu.:  21.20  -0.3    :    16   3rd Qu.: 81.04
## Max.    : 120.90  -0.2    :    15   Max.    :256.48
## NA's    :19216   (Other):  318   NA's    :19216
## amplitude_pitch_dumbbell amplitude_yaw_dumbbell total_accel_dumbbell
## Min.      :  0.00          :19216   Min.      :  0.00
## 1st Qu.: 17.06          #DIV/0!:    5   1st Qu.:  4.00
## Median : 41.73          0.00    :   401   Median :10.00
## Mean    : 65.93          :          Mean    :13.72
## 3rd Qu.: 99.55          :          3rd Qu.:19.00
## Max.    :273.59          :          Max.    :58.00
## NA's    :19216
## var_accel_dumbbell avg_roll_dumbbell stddev_roll_dumbbell
## Min.      :  0.000   Min.      :-128.96   Min.      :  0.000
## 1st Qu.:  0.378   1st Qu.: -12.33   1st Qu.:  4.639
## Median :  1.000   Median :  48.23   Median : 12.204
## Mean    :  4.388   Mean    :  23.86   Mean    : 20.761
## 3rd Qu.:  3.434   3rd Qu.:  64.37   3rd Qu.: 26.356

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## Max. :230.428 Max. : 125.99 Max. :123.778
## NA's :19216 NA's :19216 NA's :19216
## var_roll_dumbbell avg_pitch_dumbbell stddev_pitch_dumbbell
## Min. : 0.00 Min. : -70.73 Min. : 0.000
## 1st Qu.: 21.52 1st Qu.: -42.00 1st Qu.: 3.482
## Median : 148.95 Median : -19.91 Median : 8.089
## Mean : 1020.27 Mean : -12.33 Mean :13.147
## 3rd Qu.: 694.65 3rd Qu.: 13.21 3rd Qu.:19.238
## Max. :15321.01 Max. : 94.28 Max. :82.680
## NA's :19216 NA's :19216 NA's :19216
## var_pitch_dumbbell avg_yaw_dumbbell stddev_yaw_dumbbell
## Min. : 0.00 Min. : -117.950 Min. : 0.000
## 1st Qu.: 12.12 1st Qu.: -76.696 1st Qu.: 3.885
## Median : 65.44 Median : -4.505 Median : 10.264
## Mean : 350.31 Mean : 0.202 Mean : 16.647
## 3rd Qu.: 370.11 3rd Qu.: 71.234 3rd Qu.: 24.674
## Max. :6836.02 Max. : 134.905 Max. :107.088
## NA's :19216 NA's :19216 NA's :19216
## var_yaw_dumbbell gyros_dumbbell_x gyros_dumbbell_y
## Min. : 0.00 Min. : -204.0000 Min. : -2.10000
## 1st Qu.: 15.09 1st Qu.: -0.0300 1st Qu.: -0.14000
## Median : 105.35 Median : 0.1300 Median : 0.03000
## Mean : 589.84 Mean : 0.1611 Mean : 0.04606
## 3rd Qu.: 608.79 3rd Qu.: 0.3500 3rd Qu.: 0.21000
## Max. :11467.91 Max. : 2.2200 Max. :52.00000
## NA's :19216
## gyros_dumbbell_z accel_dumbbell_x accel_dumbbell_y accel_dumbbell_z
## Min. : -2.380 Min. : -419.00 Min. : -189.00 Min. : -334.00
## 1st Qu.: -0.310 1st Qu.: -50.00 1st Qu.: -8.00 1st Qu.: -142.00
## Median : -0.130 Median : -8.00 Median : 41.50 Median : -1.00
## Mean : -0.129 Mean : -28.62 Mean : 52.63 Mean : -38.32
## 3rd Qu.: 0.030 3rd Qu.: 11.00 3rd Qu.: 111.00 3rd Qu.: 38.00
## Max. :317.000 Max. : 235.00 Max. : 315.00 Max. : 318.00
##
## magnet_dumbbell_x magnet_dumbbell_y magnet_dumbbell_z roll_forearm
## Min. : -643.0 Min. : -3600 Min. : -262.00 Min. : -180.0000
## 1st Qu.: -535.0 1st Qu.: 231 1st Qu.: -45.00 1st Qu.: -0.7375
## Median : -479.0 Median : 311 Median : 13.00 Median : 21.7000
## Mean : -328.5 Mean : 221 Mean : 46.05 Mean : 33.8265
## 3rd Qu.: -304.0 3rd Qu.: 390 3rd Qu.: 95.00 3rd Qu.: 140.0000
## Max. : 592.0 Max. : 633 Max. : 452.00 Max. : 180.0000
##
## pitch_forearm yaw_forearm kurtosis_roll_forearm
## Min. : -72.50 Min. : -180.00 :19216
## 1st Qu.: 0.00 1st Qu.: -68.60 #DIV/0!: 84
## Median : 9.24 Median : 0.00 -0.8079: 2
## Mean : 10.71 Mean : 19.21 -0.9169: 2
## 3rd Qu.: 28.40 3rd Qu.: 110.00 -0.0227: 1
## Max. : 89.80 Max. : 180.00 -0.0359: 1
## (Other): 316
## kurtosis_pitch_forearm kurtosis_yaw_forearm skewness_roll_forearm
## :19216 :19216 :19216
## #DIV/0!: 85 #DIV/0!: 406 #DIV/0!: 83
## -0.0073: 1 -0.1912: 2

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## -0.0442:      1                      -0.4126:      2
## -0.0489:      1                      -0.0004:      1
## -0.0523:      1                      -0.0013:      1
## (Other):    317                      (Other):    317
## skewness_pitch_forearm skewness_yaw_forearm max_roll_forearm
##      :19216                      :19216      Min.      :-66.60
## #DIV/0!:    85                      #DIV/0!:   406      1st Qu.:   0.00
## 0.0000 :      4                      Median :  26.80
## -0.6992:      2                      Mean    :  24.49
## -0.0113:      1                      3rd Qu.:  45.95
## -0.0131:      1                      Max.    :  89.80
## (Other):    313                      NA's    :19216
## max_pitch_forearm max_yaw_forearm min_roll_forearm min_pitch_forearm
## Min.      :-151.00      :19216      Min.      :-72.500      Min.      :-180.00
## 1st Qu.:   0.00      #DIV/0!:   84      1st Qu.:  -6.075      1st Qu.: -175.00
## Median : 113.00      -1.2 :   32      Median :   0.000      Median :  -61.00
## Mean    :  81.49      -1.3 :   31      Mean    :  -0.167      Mean    : -57.57
## 3rd Qu.: 174.75      -1.4 :   24      3rd Qu.: 12.075      3rd Qu.:   0.00
## Max.    : 180.00      -1.5 :   24      Max.    :  62.100      Max.    : 167.00
## NA's    :19216      (Other):  211      NA's    :19216      NA's    :19216
## min_yaw_forearm amplitude_roll_forearm amplitude_pitch_forearm
##      :19216      Min.    :   0.000      Min.    :   0.0
## #DIV/0!:   84      1st Qu.:   1.125      1st Qu.:   2.0
## -1.2 :   32      Median : 17.770      Median :  83.7
## -1.3 :   31      Mean    : 24.653      Mean    :139.1
## -1.4 :   24      3rd Qu.: 39.875      3rd Qu.:350.0
## -1.5 :   24      Max.    :126.000      Max.    :360.0
## (Other):  211      NA's    :19216      NA's    :19216
## amplitude_yaw_forearm total_accel_forearm var_accel_forearm
##      :19216      Min.    :   0.00      Min.    :   0.000
## #DIV/0!:   84      1st Qu.: 29.00      1st Qu.:   6.759
## 0.00 :   322      Median : 36.00      Median : 21.165
##      Mean    : 34.72      Mean    : 33.502
##      3rd Qu.: 41.00      3rd Qu.: 51.240
##      Max.    :108.00      Max.    :172.606
##      NA's    :19216
## avg_roll_forearm stddev_roll_forearm var_roll_forearm
## Min.      :-177.234      Min.    :   0.000      Min.    :   0.00
## 1st Qu.:  -0.909      1st Qu.:   0.428      1st Qu.:   0.18
## Median :   11.172      Median :   8.030      Median :   64.48
## Mean    :   33.165      Mean    :  41.986      Mean    : 5274.10
## 3rd Qu.: 107.132      3rd Qu.:  85.373      3rd Qu.: 7289.08
## Max.    : 177.256      Max.    :179.171      Max.    :32102.24
## NA's    :19216      NA's    :19216      NA's    :19216
## avg_pitch_forearm stddev_pitch_forearm var_pitch_forearm
## Min.      :-68.17      Min.    :   0.000      Min.    :   0.000
## 1st Qu.:   0.00      1st Qu.:   0.336      1st Qu.:   0.113
## Median : 12.02      Median :   5.516      Median :  30.425
## Mean    : 11.79      Mean    :   7.977      Mean    : 139.593
## 3rd Qu.: 28.48      3rd Qu.:12.866      3rd Qu.: 165.532
## Max.    : 72.09      Max.    :47.745      Max.    :2279.617
## NA's    :19216      NA's    :19216      NA's    :19216
## avg_yaw_forearm stddev_yaw_forearm var_yaw_forearm gyros_forearm_x
## Min.      :-155.06      Min.    :   0.000      Min.    :   0.00      Min.    : -22.000

```

```

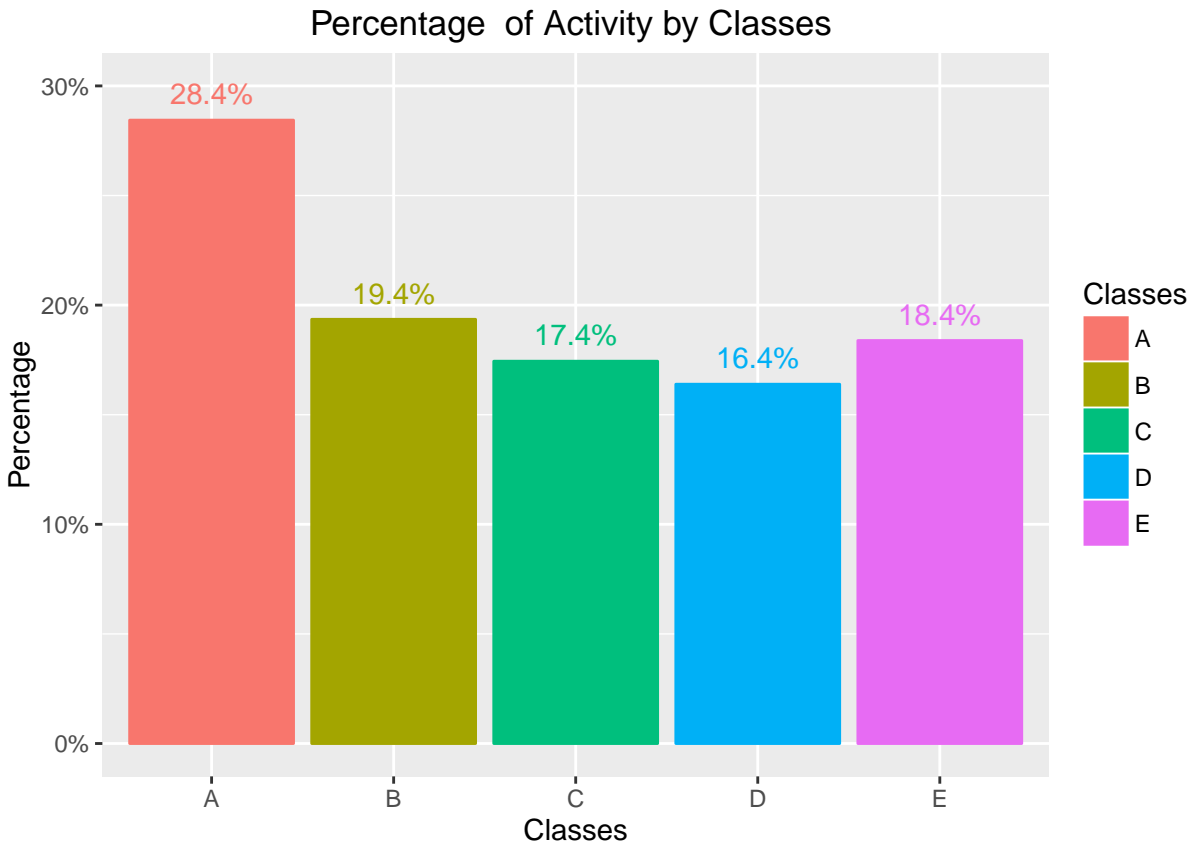
## 1st Qu.: -26.26 1st Qu.: 0.524 1st Qu.: 0.27 1st Qu.: -0.220
## Median : 0.00 Median : 24.743 Median : 612.21 Median : 0.050
## Mean : 18.00 Mean : 44.854 Mean : 4639.85 Mean : 0.158
## 3rd Qu.: 85.79 3rd Qu.: 85.817 3rd Qu.: 7368.41 3rd Qu.: 0.560
## Max. : 169.24 Max. : 197.508 Max. : 39009.33 Max. : 3.970
## NA's :19216 NA's :19216 NA's :19216
## gyros_forearm_y gyros_forearm_z accel_forearm_x accel_forearm_y
## Min. : -7.02000 Min. : -8.0900 Min. : -498.00 Min. : -632.0
## 1st Qu.: -1.46000 1st Qu.: -0.1800 1st Qu.: -178.00 1st Qu.: 57.0
## Median : 0.03000 Median : 0.0800 Median : -57.00 Median : 201.0
## Mean : 0.07517 Mean : 0.1512 Mean : -61.65 Mean : 163.7
## 3rd Qu.: 1.62000 3rd Qu.: 0.4900 3rd Qu.: 76.00 3rd Qu.: 312.0
## Max. : 311.00000 Max. : 231.0000 Max. : 477.00 Max. : 923.0
##
## accel_forearm_z magnet_forearm_x magnet_forearm_y magnet_forearm_z
## Min. : -446.00 Min. : -1280.0 Min. : -896.0 Min. : -973.0
## 1st Qu.: -182.00 1st Qu.: -616.0 1st Qu.: 2.0 1st Qu.: 191.0
## Median : -39.00 Median : -378.0 Median : 591.0 Median : 511.0
## Mean : -55.29 Mean : -312.6 Mean : 380.1 Mean : 393.6
## 3rd Qu.: 26.00 3rd Qu.: -73.0 3rd Qu.: 737.0 3rd Qu.: 653.0
## Max. : 291.00 Max. : 672.0 Max. : 1480.0 Max. : 1090.0
##
## classe
## A:5580
## B:3797
## C:3422
## D:3216
## E:3607
##
##

```

Training data consist of 19,622 and Testing data consist of 20 observations with each 160 variables

Barplot of Classes of Activity by percentage in training data set

```
training.plot
```

Pre-Processing

Pre-Process Training Data

Training data pre-processed before building model using `cleandata` function created in the R Script.

Model building

Since training set data is very large with 19,622 observations, we split to training and validation set

I sample 30% of the data for training model and 5% data for validation

```
train <- cleaneddata[sample(nrow(cleaneddata), round(0.3*(dim(training)[1]))), ]
validation <- cleaneddata[sample(nrow(cleaneddata), round(0.05*(dim(training)[1]))), ]
```

The variable to be predicted consist of 5 classess. Thus this a classification problem, as such I propose 4 models that handle classification prediction. Model with best aacuracy will used for prediction with testing data.

Model 1 - using decision tree

```
#Model1 <- train(classe~., method="rpart", data=train)
```

Model 2 - use bagging

```
#Model2 <- train(classe~., method="treebag", data=train)
```

Model 3 - use Random Forest

```
#Model3 <- train(classe~., method="rf", data=train)
```

Model 4 - use Boosting

```
#Model4 <- train(classe~., method="gbm", data=train)
```

EVALUATION OF MODELS

1. Decision Tree Model

```
model1sum
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  A   B   C   D   E
##           A 108   3   7   0   0
##           B  43  30  18   0   0
##           C  43   2  50   0   0
##           D  51  13  25   0   0
##           E  19  13  29   0  46
##
## Overall Statistics
##
##           Accuracy : 0.468
##           95% CI : (0.4236, 0.5128)
##           No Information Rate : 0.528
##           P-Value [Acc > NIR] : 0.9968
##
##           Kappa : 0.3218
##           McNemar's Test P-Value : NA
##
## Statistics by Class:
##
##           Class: A Class: B Class: C Class: D Class: E
## Sensitivity      0.4091  0.4918  0.3876      NA  1.0000
## Specificity      0.9576  0.8610  0.8787  0.822  0.8656
## Pos Pred Value   0.9153  0.3297  0.5263      NA  0.4299
## Neg Pred Value    0.5916  0.9242  0.8049      NA  1.0000
## Prevalence       0.5280  0.1220  0.2580  0.000  0.0920
## Detection Rate    0.2160  0.0600  0.1000  0.000  0.0920
## Detection Prevalence 0.2360  0.1820  0.1900  0.178  0.2140
## Balanced Accuracy 0.6834  0.6764  0.6332      NA  0.9328
```

2. Bagging Model

model2sum

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  A   B   C   D   E
##           A 538   5   2   0   1
##           B   7 349   5   2   0
##           C   1   8 346   7   0
##           D   3   2   7 331   2
##           E   0   2   0   2 342
##
## Overall Statistics
##
##           Accuracy : 0.9715
##           95% CI : (0.9631, 0.9784)
##           No Information Rate : 0.2798
##           P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.964
##           McNemar's Test P-Value : NA
##
## Statistics by Class:
##
##           Class: A Class: B Class: C Class: D Class: E
## Sensitivity           0.9800   0.9536   0.9611   0.9678   0.9913
## Specificity           0.9943   0.9912   0.9900   0.9914   0.9975
## Pos Pred Value        0.9853   0.9614   0.9558   0.9594   0.9884
## Neg Pred Value        0.9922   0.9894   0.9913   0.9932   0.9981
## Prevalence            0.2798   0.1865   0.1835   0.1743   0.1758
## Detection Rate        0.2742   0.1779   0.1764   0.1687   0.1743
## Detection Prevalence  0.2783   0.1850   0.1845   0.1758   0.1764
## Balanced Accuracy      0.9872   0.9724   0.9756   0.9796   0.9944
```

3. Random Forest Model

model3sum

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  A   B   C   D   E
##           A 543   2   1   0   0
##           B   3 357   3   0   0
##           C   0   2 358   2   0
##           D   0   0 11 333   1
##           E   0   0   0   0 346
##
## Overall Statistics
```

```
##
##           Accuracy : 0.9873
##           95% CI : (0.9812, 0.9917)
##      No Information Rate : 0.2783
##      P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.9839
##  McNemar's Test P-Value : NA
##
## Statistics by Class:
##
##           Class: A Class: B Class: C Class: D Class: E
## Sensitivity      0.9945  0.9889  0.9598  0.9940  0.9971
## Specificity      0.9979  0.9963  0.9975  0.9926  1.0000
## Pos Pred Value   0.9945  0.9835  0.9890  0.9652  1.0000
## Neg Pred Value   0.9979  0.9975  0.9906  0.9988  0.9994
## Prevalence       0.2783  0.1840  0.1901  0.1707  0.1769
## Detection Rate   0.2768  0.1820  0.1825  0.1697  0.1764
## Detection Prevalence 0.2783  0.1850  0.1845  0.1758  0.1764
## Balanced Accuracy 0.9962  0.9926  0.9786  0.9933  0.9986
```

4. Gradient Boosting Model

```
model4sum
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  A   B   C   D   E
##           A 117   0   1   0   0
##           B   5  81   3   0   2
##           C   1   6  85   3   0
##           D   0   0   2  87   0
##           E   0   3   0   3 101
##
## Overall Statistics
##
##           Accuracy : 0.942
##           95% CI : (0.9178, 0.9608)
##      No Information Rate : 0.246
##      P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.9273
##  McNemar's Test P-Value : NA
##
## Statistics by Class:
##
##           Class: A Class: B Class: C Class: D Class: E
## Sensitivity      0.9512  0.9000  0.9341  0.9355  0.9806
## Specificity      0.9973  0.9756  0.9756  0.9951  0.9849
## Pos Pred Value   0.9915  0.8901  0.8947  0.9775  0.9439
## Neg Pred Value   0.9843  0.9780  0.9852  0.9854  0.9949
```

## Prevalence	0.2460	0.1800	0.1820	0.1860	0.2060
## Detection Rate	0.2340	0.1620	0.1700	0.1740	0.2020
## Detection Prevalence	0.2360	0.1820	0.1900	0.1780	0.2140
## Balanced Accuracy	0.9743	0.9378	0.9548	0.9653	0.9827

ACCURACY

Based on the accuracy of the above 4 confusionmatrix, both Model 2 and Model 3 perform better than Model 1 and Model 4 . Between Model 2 and Model 3, Model 2 perform slightly better. As such Model 2 choosed to predict the validation data set with 20 observations.

Prediction on the Testing Data set

Clean the testing data set

```
#testing_data<- cleandata(testing)
```

Get the predictions

```
#testing_predict <- predict(Model2,newdata = testing_data)
```

My final predictions are :

```
testing_predict
```

```
## [1] B A B A A E D B A A B C B A E E A B B B
## Levels: A B C D E
```

Note: The detail code for this project is found in the github. Please click [Quantifying Effectiveness of Activity.R in the Github.](#)

REFERENCE

The above study and data for this project was genourosly shared by:

Velloso, E.; Bulling, A.; Gellersen, H.; Ugulino, W.; Fuks, H. Qualitative Activity Recognition of Weight Lifting Exercises. Proceedings of 4th International Conference in Cooperation with SIGCHI (Augmented Human '13) . Stuttgart, Germany: ACM SIGCHI, 2013.

More information is available from the website here: <http://groupware.les.inf.puc-rio.br/har> (see the section on the Weight Lifting Exercise Dataset).